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ABSTRACT

This document is a verbatim transcription of an interview conducted by Thomas C. O'Brien under the auspices of the Teacher's Center Project of Southern Illinois University at Edwardsville. The transcript presents the views of Professor A. I. Weinzweig for the University of Illinois at Chicago Circle. Distinctions between training and education, and a feeling that much of what American education offers is training for a world that no longer exists, are noted. Ideas about the ways young children learn and solve problems within specific contexts and ideas for teaching that recognize the cognitive nature of children are also presented. (MP)

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LEARNING AND CONTEXT

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with
A.I. Weinzweig
University of Illinois at Chicago Circle
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O'Brien: I am Tom O'Brien from the Teachers' Center Project and I am delighted to introduce to you Professor A.I. Weinzweig from the University of Illinois at Chicago Circle. With us today as well is Professor Cam Meredith of SIU: Let me introduce my friend, Izzy. We have known him for three or four years but this is his first visit to SIU. I am grateful that you could come and I hope that this is the first of many visits.

Weinzweig: I hope so.

O'Brien: Professor Weinzweig is a member of the advisory board of the Second International Study of Mathematics and he is a newly elected member of the International Commission for the Improvement of Teaching and Learning Mathematics. He is a distinguished mathematician and recently he has been seduced by this business that engages so many of us: what about young children, how do they grow? In particular, how do they grow and

learn in the area of mathematics? Izzy has many sensible things to say and he has a reputation of saying them -- not withholding them. Let's start, Izzy -- Cam is going to join in on our discussion -- by asking broad questions. You have in your speeches in various places drawn a distinction between training and education. What about that distinction?

Weinzweig: Well, I object to calling courses for teachers teacher training programs. You train animals. You <u>educate</u> people. When we talk about training we think in terms of performing certain tasks without any thinking. If my Latin serves me well, to educate means to lead out. You want to lead a child out into learning. I think that training and that sort of thing go on in schools too often. We try to inject or insert knowledge into children. We try to get them to perform a certain way, whereas what we ought to be doing is to lead the child so that he or she learns. What we should want them to do is to arrive at a higher level of understanding and relational understanding. If a child can say what 8 + 7 is, that is fine. That's instrumental. If he knows when to add 8 and 7 in order to solve a particular problem, that could be relational learning. I am more concerned that he know when to add and know why to add than that he simply tell me what 8 + 7 is. That is conditioning, it is training, it is the kind of thing you teach a dog or a horse to do. But a child is a human being with a thinking mind and we have to engage that in a stronger way than we usually do in the educational enterprise.

O'Brien: You have made the point that much of what happens in American education amounts to training, and, in fact, you have suggested that this often is training for a world that no longer exists.

Weinzweig: Oh, yes. I will give an example of that. When I was a child in Canada things were more backward than they are these days. I would go to the corner grocery store and make some purchases for my mother and the grocer would collect all the items on the counter, take a paper bag and write each item's price, and add up the prices. If you had a cash register and something went wrong with it, you could tinker with it and fix it. Today you go into a supermarket and the checkout person simply punches messages into a cash register which is really a computer. In fact, sometimes they just punch in the items and the computer rings up what the price is. And now there may be a scanner which will ring up what the price is and the computer will not only add up the prices but also keep track of inventory. Now you hand the clerk a $10 bill, he or she punches that fact into the cash register, and the machine will automatically ring up how much change you are supposed to get.

The skill that is needed there is a much different kind of skill than is needed by the grocer when I was a child. And if that computer, calculator or cash register goes on the blink, you can't tinker with it. The level of technology needed to repair it often requires a good engineering degree from a top-notch university.

So the world that we live in has changed drastically but I think we still are teaching children to do things as if we were living fifty years ago.

Take another example. We spend a lot of time today teaching kids how to do long division. As a mathematician, I can't remember doing a long division where I actually did it with paper and pencil. If I need to do long

division and I have a lot to do, I use a calculator. Calculators aren't something new. Years ago I worked in geophysics and we had calculators to do many types of problems. I think E.L. Thorndike -- the psychologist who was probably most responsible for the theory on which most American education is based (which says you train children, you train children, you train children) — wrote in 1920 that it is foolish to waste time teaching children to add columns of numbers because anyone who has to add columns of numbers will have a machine to do it.

O'Brien: Even he said that, and that was some 60 years ago.

Weinzweig: Sixty years ago. And here is the man who developed that theory of connections and conditioning and drill and the kind of learning that goes on in so many classrooms. And sixty years ago he said it is foolish to teach children to do long, complicated addition problems because they will have a machine to do them. Today we are still trying to teach children to do these problems. Today we have machines that will do a lot more than the machines available in 1920.

Meredith: Things like keeping track of costs in shopping and keeping a checkbook -- these can be done so much better by machine.

Weinzweig: And the problem with keeping your checkbook and totalling shopping costs isn't really the calculations or the computations; it is knowing what to do. Balancing your checkbook isn't a matter of subtraction. A little calculator for $5.95 will do subtraction for you. It is knowing how to enter things into a checkbook. It is knowing what to subtract and what to add that is the confusing aspect of it. This has nothing to do with calculations.

O'Brien: And what do these lines on the printout mean when you get your monthly statement from the bank?

Weinzweig: Precisely. So I think that the kind of understanding that people need to function in our society today is quite different from what it used to be. I think that it is foolish for us to spend a great deal of time teaching children to do what they will never do in real life, things that a $5 gadget will do. The human mind is capable of so much more. It is ridiculous to clutter it with this kind of useless stuff.

Meredith: We can go further than that. We can have a savings account which automatically transfers to the checking account. And if you really make an error, you can have a "master charge" that will give you so much and you pay a little interest. After a few months you get a pretty good idea what you can spend and what you can't spend.

Weinzweig: Right. That is where the mathematics comes in. I think that mathematics is more a way of thinking. Mathematics is the art of trying to decide what will happen if I decide to do something. Without actually having to do it. I have a space in my dining room and I want to buy a buffet.

O'Brien: You don't move the buffet in.

Weinzweig: I don't move the buffet in until I know it will fit. I measure the buffet and I measure the space that it is going to fit so I know what is going to happen if buy the buffet. But I don't move it in at the start. That is how I use mathematics. I think it is the using of the mathematics which is the relevant thing. I think that too much of what goes on in the schools is divorced from the context in which we use the mathematics.

The result is that the level on which the schools function is really the simple training of children to perform. To recite. You give him a 3+4 and he answers back a 7. Who in his right mind would want to know that 3 and 4 equals 7 unless you have a use for it? It is because it's useful that we want to learn things. Yet we never present things in context to children. We never suggest that it is worthwhile learning that 3+4=7 because you can apply that in lots of different contexts and save yourself a lot of trouble by not having to deal with every new context as a new situation. That is what the essence of mathematics is all about.

Meredith: Math is widely used for one overriding purpose: to have the children behave and do what they are to do and be under control. The whole process is indoctrinating and reinforcing the idea that you do what the teacher tells you to do. Then you will make out all right in school.

Weinzweig: Oh, I think that is absolutely true. And mathematics has another function in school which as a mathematician I find abhorrent: that is to weed kids out. A lot of intelligence tests use certain mathematical tasks as a way of deciding which are the lambs and which are the goats. Many intelligence tests involve spatial visualization. Now most people have a lot of trouble with this. And I think the reason is that they have had a lot of experience in visualizing things but they never focus, they never really know what to look for, what to look at, when they see things. People who have a natural ability for this sort of thing pick up certain clues without being aware that they are picking up these clues. I got intrigued with this question a couple of years ago. I took a group of teachers in the summer and I said, "Let's do some work with geometry."

(I have an engineering background and I work in geometry, so I have good spatial visualization. But I try to look at these things from a teacher's point of view. What must a teacher attend to? What little things that you attend to give you a clue? How to see things?) Now part of the problem, of course, is that when you talk of spatial visualization you are usually presented with a two-dimensional representation of something which is three-dimensional. Well, that is a code, just as reading or writing is a code. You have to learn how to decipher the code. And you have to learn to attend to certain kinds of things and not to attend to others.

Meredith: How do you learn what to attend to?

Weinzweig: As a mathematician I found the task a very difficult one because I automatically did things without being aware of what I was doing. But as I began to think about it I began to notice certain kinds of things. In the summer with teachers I would give them tasks which would be too difficult to put on an intelligence test and teachers who initially had absolutely no ability at all were able to do them with no difficulty.

O'Brien: As in driving, you don't necessarily attend to the color of every car that passes you. You <u>do</u> attend to the fact that a car is swerving into your direction or not swerving into your direction.

Weinzweig: Right.

O'Brien: So one major aspect, then, in respect to the growth of intellect is to learn what to attend to and what to ignore.

Weinzweig: That's right. I think we are constantly confronted with a whole mass (or mess) of input. And we have to distinguish between the information and the background noise. Okay? So we attend to what we think

is the important information. Now sometimes what is relevant isn't immediately apparent. I'm sure you have all had the experience where you give people a certain set of instructions and they start carrying them out and then halfway through they get stuck and they say, "I don't know what to do next," and then you repeat the instructions and they say, "Oh, I see." Your natural response is, "I gave you all this information before." The fact is that it wasn't that they weren't listening, but that they attended only to what they thought was relevant. And some of the information you gave them didn't appear to be relevant at that time. As they got into the task they were confronted with a situation that they didn't have enough information to deal with. At that point the information that you now give to them is relevant because it is related to the particular context in which they are functioning and operating. Now they can take this information and assimilate it and use it.

O'Brien: That says, for one thing, watch out where the child is, don't give them the whole flow of information or the whole flow of instruction right off the bat in one package.

Weinzweig: Exactly. In fact, I find that when I do things with kids -- with students on every level -- I give only enough information to get started. I lay out the rules of the game, so to speak. And as we progress as they get into the task, as they confront situations, I say, "Now I'm going to introduce a new rule." Often the new rule will help them avoid situations which are not useful. At the time the rule has relevance because they're dealing with it in a particular context. They can see what the problem is. They may need to eliminate a particular part and I say, "No,

we don't want to consider that; we will rule that out." If I had tried to give them all the rules at the beginning, it would have been more frustrating to them and it would have been more frustrating to me. I would say, "I just explained this to you." And the poor student would say, "But I didn't understand it." So he feels that he is stupid, I feel that he is stupid, and I feel that the class is not listening. The actual fact is that they are listening, they are attending, but they can't put all the pieces together all at the start.

O'Brien: Let's talk a little about context. Context for you seems to be a very important issue.

Weinzweig: Well, when we talk about kids' learning, the kinds of things we want them to learn are concepts. What type of mathematics, what type of mathematical concepts? I think that mathematical concepts -- and concepts in general -- aren't something which come out of the air. I think we can create or formulate — I am not quite sure what the appropriate term is -- but we develop a concept to deal with particular situations and in particular contexts.

O'Brien: For example?

Weinzweig: Well, let's talk about numbers. We use the word number as if it has a very specific, well defined meaning. Yet if you listen very carefully you will find that people talk about number in lots of different ways. To illustrate that point I use a trick when I am dealing with a group of teachers. I call upon someone in the audience and say, "Count." And of course the person stands up and says, "1, 2, 3, 4, 5, 6." Then I will show them a handful of blocks, and I will say, "Count," and the person will point

and gesture and say, "1, 2, 3, 4, 5, 6." Now I used exactly the same "command" but the responses are quite different.

We use the word "count" to apply to completely different activities and completely different actions. Now counting is of course related to number. But we use numbers in different ways. As a mathematician who is interested in how children learn, I want children to develop an understanding of number. First I have to ask myself, "Why are they interested in number?" "What are the problems that they are going to confront when they use number?" And "How are they going to use number?"

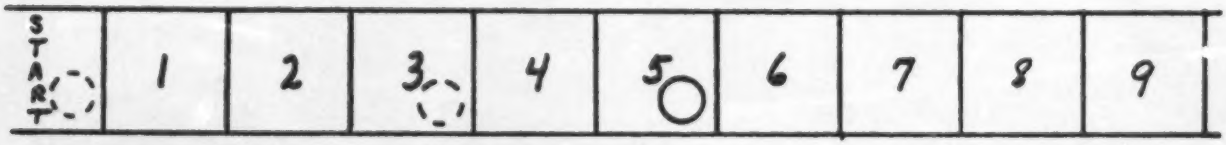
One of my favorite examples is the following: I have a bag of cookies and a group of children. And being the sweet, kind, considerate person that I am I want to give each of these children a cookie. But I know from experience that if I start handing out the cookies and some of the kids don't get cookies, then I have a major problem on my hands. So what I want to do is to find out what will happen -- what will be the outcome of that action -- without actually carrying out the action. Well I can do that. I can count the number of children and I can count the number of cookies. And if the number of cookies isn't less than the number of children, then I am in business; I can hand out the cookies and I'm on safe ground.

Here I'm talking about a particular notion of number, which is related to what we can call numerosity. Counting is related to that. And I'm dealing with a particular problem in a particular context. If I want children to get this idea, then I have to take a close look at what goes on with number and counting and then I've got to create the context for the children so that

they construct their notion of number from these contexts.

Then you create different contexts. What happens is that the child is creating a notion of number to deal with one context, then he or she creates a different notion of number to deal with another context, and another notion to deal with still another context. After a while the child begins to recognize that if he or she does a task in one context, he can shift to another context and do the same kind of task and get the same answer.

Let me give you a specific example to illustrate this sort of thing. One of the things that I like to do with children is to work with what I call a number track. Here is the context. I have a die and I throw it. And suppose I get a three. Well, I have a marker and I move the marker



three spaces, and we end up here. Then I throw the die again and I get a two. Now I move the marker two more spaces and I end up on five. This is a situation that children are familiar with. They play games, they do this all the time. Now one of the aspects of mathematics which is quite important is keeping a record of what you are doing. This involves developing a written language, a notation. This is something that we really don't recognize as being as important as it really is.

So we develop a written language. What is the relevant information? Well, the first roll was a three, the second roll was a two, and I ended upon five. We can develop the notation in lots of different ways. We can

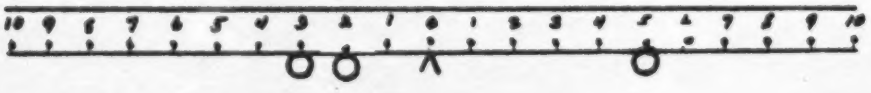
write it like this: 3/2/5. That is really a language, a written language, and in this case it is read by the child as, "I got a three on my first throw, I got a two on my second throw, and I ended up on five. We can switch to a different form of recording the information. We can say: 3+2=5. Here again "3+2=5" has nothing to do with numbers in the abstract. It means that on my first throw I got a three, on my second throw I got a two, and I ended up on five.

O'Brien: So in this case "3+2=5" has one contextual meaning.

Weinzweig: Yes.

O'Brien: It means you rolled a three followed by a two, and you wound up on five.

Weinzweig: It means just that and nothing more than that. Now I can make a different context. A number balance. You have a bar which pivots. And you have pegs here.



Okay. In this context I put a weight on peg three, for instance. Then I put another weight on peg two. And now the task is to put a weight on the other side so that the bar will balance. If I put the weight on five, it will just balance. Now in this situation children can experiment and come up with the answer. There is a context in which they can function.

Again we can develop a way to record the information. By pure coincidence, we develop the language that 3 + 2 = 5. In this context it means

that if I put a weight on the three and another weight on the two, I can balance it by a weight on the five on the other side.

O'Brien: It is obvious from what you are saying that much of the work that kids do in school has no context whatsoever.

Weinzweig: Precisely. A lot of the teaching that goes on in schools is presenting information with absolutely no context. And so the child has no way of grasping it. The child has no way to come up with a solution. If we can give him a problem in a context, he can come up with the answer. Even if he doesn't remember what 3 + 2 is, he can come up with the situation and reconstruct the 3 + 2.

After a while he begins to discover that if I give 3 + 2 = 5 -- just like that, without a context -- he can't tell you what context it is from. He can't tell whether I was describing this context or that context. So he confronts the question, does it matter which context? And he discovers that it doesn't matter. So he begins to develop a context-free understanding of 3 + 2 = 5. He begins to realize that if he knows that 3 + 2 = 5 in one context, then it is going to apply to every context. Now he has a reason for learning that 3 + 2 = 5. It is a labor-saving device. If he knows that 3 + 2 = 5, he doesn't have to figure it out in any particular context (though he can if need be).

O'Brien: This gives him a great deal of power.

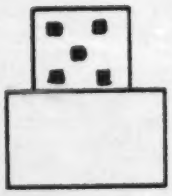
Weinzweig: Absolutely. Mathematics is powerful. One can talk about the imperialism of mathematics. Today in almost every area you come into, mathematics has a very important role. The reason is that the mathematician develops mathematics to a context-free situation which we can then apply to

all kinds of different contexts. But what people forget is that mathematics originally arose out of some context. Then by abstracting some context to a context-free situation you give yourself the power of applying the issue to other contexts.

O'Brien: So your advice to the teachers is what?

WEinzweig: I think that if you are going to help a child to develop a concept, you must think of the context in which the concept arises, present the child with the concept, and let the child function within the context so that he begins to confront the problem, develop the concept to deal with the problem, and structure his experiences and organize his experiences. And then one must provide other contexts in order to focus the child's attention on the fact that if he does a problem in one context and gets an answer and then does the same kind of problem in a different context, he is going to get the same answer. Ultimately, the child becomes free to change the context he wants to operate in.

As an example of this, let me tell you about something that actually happened. A child was presented with a card and part of the card was covered by another card.



There were five blocks showing and the child was told that there were four blocks under the cardboard screen. How many blocks are there in all?

The information that was presented to the child was presented in two

different forms. The information about the five was visible. The information about the four was given in a more abstract form, in words. What the child did was to shift both contexts into a new context, fingers. She went, "Five. Six, seven, eight, nine." What was interesting to me in this simple example was that she jumped from the context of cards with dots on them (and words giving her information) to a context which was easy for her to deal with, fingers. Before I got interested in working with children, I would have expected her to say, "Five plus four equals nine." For me as an adult, I could work in a context-free situation five plus four equals nine. That would give me the answer for this particular context. This is not the way children function. But what this child did -- and many children will do the same -- is very impressive. She shifted from two contexts to a completely different context. In doing that she showed that she was aware that it didn't matter which context she worked in -- that she could shift from the context to a completely different context, solve the problem in the new context, and transfer the answer she got to the original context. She still hadn't learned to develop this information as context-free, so she didn't recognize the usefulness of knowing that $5 + 4 = 9$, but that will be a later stage in her learning. Once she becomes aware of the usefulness of shifting from one context to another, that she can shift freely from one context to another, then it becomes useful to learn these things without a particular context so that you can apply them to all kinds of contexts.

It is that shifting from a context-bound situation to a context-free situation which is missing in education. We always operate under a context-

free situation with children and the child doesn't have any idea of why or how or where these things come from.

There's a saying, "If you would give a man a fish, you feed him for a day. But if you teach him how to fish, you will feed him for life." In a sense, that is what I am trying to say here. I don't want just to give him a fish, I want to teach him how to fish.

O'Brien: Time to close off. I would like to go back to the beginning of your session where you talked about attending to relevant and irrelevant information. I would like, if you would, to put in the problem of the two mathematicians who met at the conference. Let's leave that with people.

Weinzweig: Okay. One often finds in many textbooks all kinds of advice on problem solving. One of the things is, "Look at the data, understand the data, and then you go on and solve the problem." But if you watch what we do in solving a problem, not what we say we do, you'll see that we don't operate in that way. One of my favorite problems to bring this point out (and by saying this I am giving a hint to the solution of the problem) is the following: Two mathematicians are discussing mathematics as they are walking back and forth along the street. After they finish their discussion on mathematics, one says to the other, "Do you have any children?" And the other says, "Yes." "How many?" "Three." "How old are they?" "Well, the product of their ages is 36." And the second mathematician says, "There is not enough information." And the first mathematician looks up and says, "Do you see that house number? That is the sum of their ages." The second mathematician says, "That still is not enough information." So the

first one says, "Well, the oldest is visiting her grandmother." How old are the children?

O'Brien: With that, I thank Izzy Weinzweig and Cam Meredith for joining us. A delightful chat. Let's hope for future visits and lots of them.